

EP155 MIDTERM EXAM
Feb. 12, 2003

Student name _____ Student No. _____

TIME: 1.5 HOURS

One 8.5X11 sheet of paper and calculator allowed

Constants

$$k = 9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$$

$$\text{charge on an electron} = -1.602 \times 10^{-19} \text{ C}$$

$$\text{resistivity of copper at } 20^\circ\text{C} = 1.723 \times 10^{-8} \Omega \cdot \text{m}$$

$$\text{resistivity of aluminum at } 20^\circ\text{C} = 2.825 \times 10^{-8} \Omega \cdot \text{m}$$

$$\text{inferred absolute zero temperature for copper} = -234.5^\circ\text{C}$$

$$\text{inferred absolute zero temperature for aluminum} = -236^\circ\text{C}$$

Q1 _____

Q2 _____

Q3 _____

Q4 _____

Q5 _____

Q6 _____

Q7 _____

Total _____

(8)

1. Figure 1 shows the location of two positively charged particles, Q_1 and Q_2 . The particle denoted Q_1 has a positive charge of 0.5 nC and the particle denoted Q_2 has a positive charge of 2.0 nC. The two particles have (x,y) coordinates (2,2) and (10,10) respectively, where each coordinate has units centimeters.

- (a) Find the total force on a test charge, say Q_t , of $+2 \times 10^{-2}$ C when it is at point A (point A has coordinates (6,2)).
- (b) How much work is required to move the test charge from point A to point B (point B has coordinates (6,10))?
- (c) What is the electric potential of +1 C of charge at point B w.r.t. point A (i.e. what is V_{BA})?
- (d) Show the electric field vector in Figure 1 at point D (point D has coordinates (8,8)). Clearly indicate direction with an arrow (vector) and mark the electric strength (magnitude) along its side.

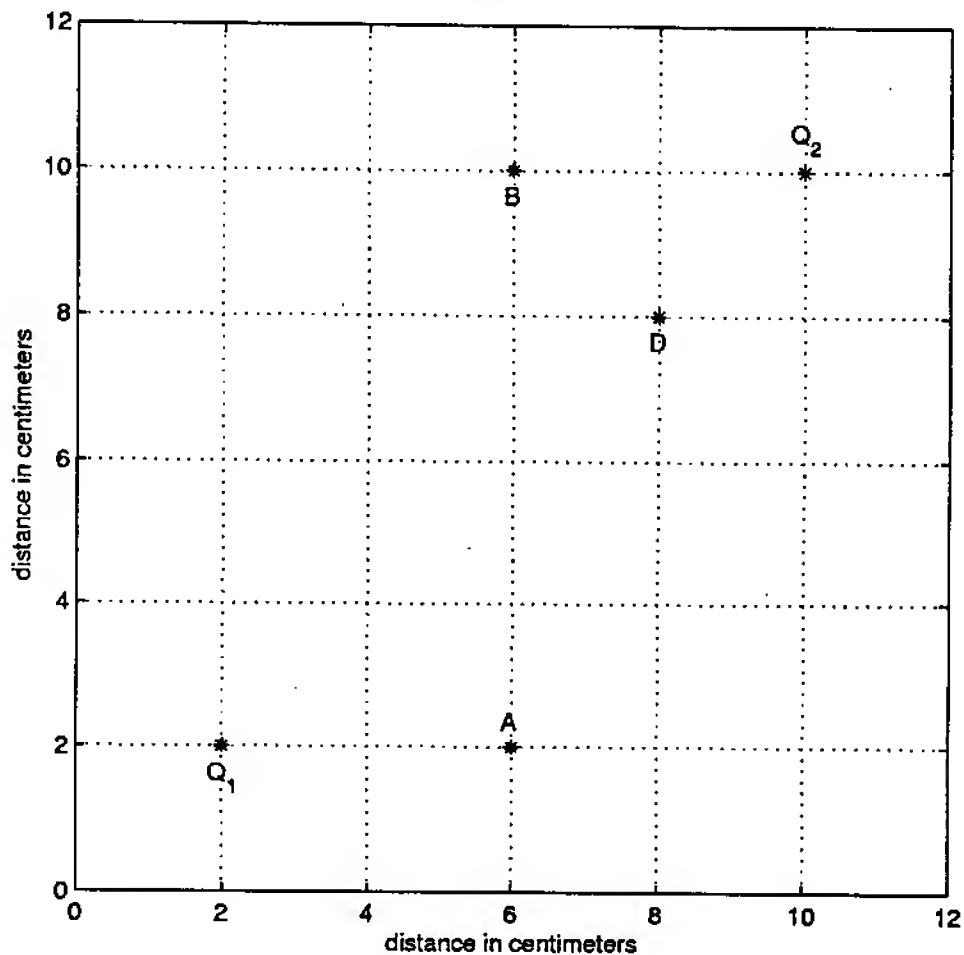


Figure 1: Charge is located at points Q_1 and Q_2

(9)

2. Figure 2 shows equipotential contours in an electric field. The map is not drawn to scale but has distance marked on the x and y axes. The contour lines represent 1 volt steps. The voltage of point B w.r.t. point A is 7 volts.

- Draw the electric field line that passes through point D. Be sure to mark the direction.
- What is the electric potential of +1 C of charge at point B w.r.t. point D?
- Approximately what is the magnitude of the electric force on a particle with +7 mC of charge if that particle is placed at point F.
- Some test charge, Q_t , of unknown amount and sign is placed at A. This charge experiences a total electric force of 10 N. It is known that the y component of the electric force is positive (i.e. upward).
 - What is the sign of the test charge?
 - Approximately, what is the magnitude of Q_t ?
 - Approximately, what is the x component of the electric force (i.e. force in horizontal direction)?

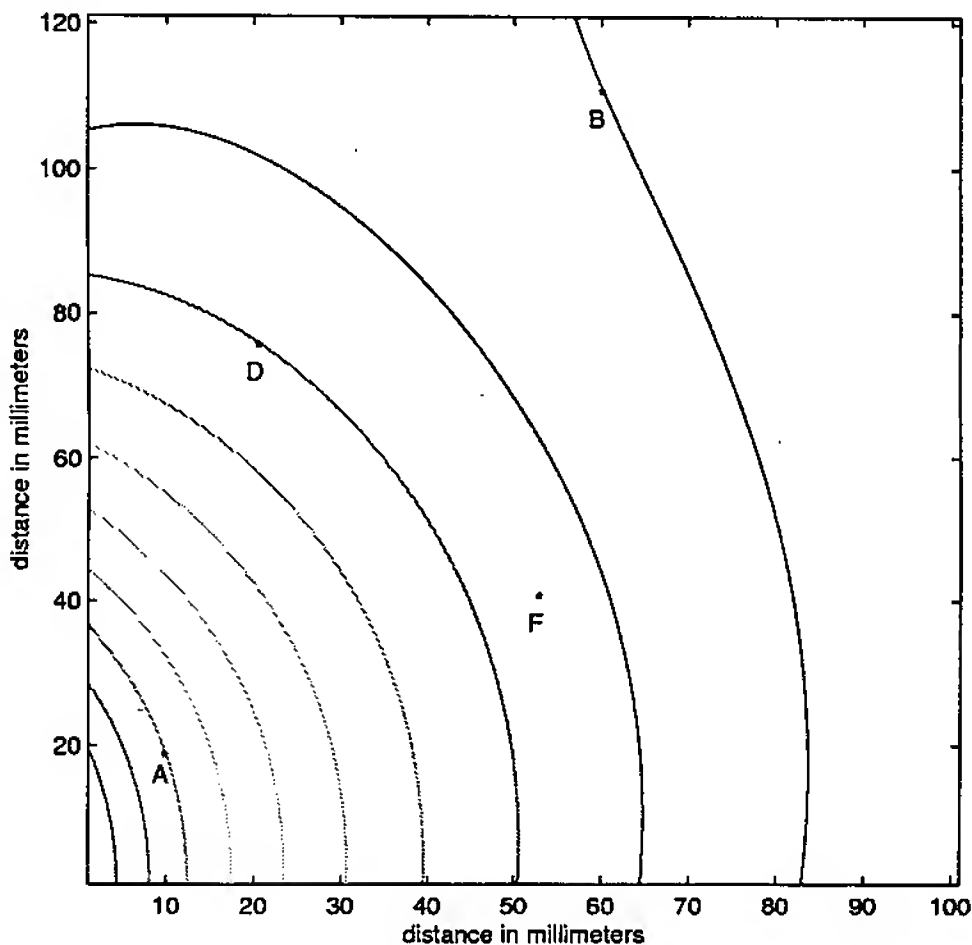


Figure 2

- (6)
3. An aluminum wire 1500 m long has a resistance of 7 ohms. A copper wire has the same cross section area as the aluminum wire but is 1000 m long. The two wires are connected in series. Both wires are at a temperature of 20 degrees centigrade.
- (a) What is the resistance of the two wires in series?
 - (b) What is the resistance of just the aluminum wire, if the temperature of the aluminum wire is changed to -50°C ?
 - (c) What is the temperature coefficient at 20°C of the dual composition resistor which is the aluminum and copper wires connected in series?

- (6)
4. A resistor has a temperature coefficient of $0.007^{\circ}\text{C}^{-1}$ at 20°C . It has a resistance of $100\ \Omega$ at 50°C . What is its resistance at 0°C ?

- (6)
5. A series circuit is shown in Figure 3. The current flowing in the circuit is 10 mA clockwise. The values of resistor R_1 and battery E are unknown.
- (a) What is V_{AB} ? The sign of your answer must be correct to get full credit for this question.
 - (b) At what rate is energy converted from chemical energy to electrical energy by the 20 V battery. The sign of your answer must be correct to get full credit for this question.
 - (c) If R_1 converts electrical energy to heat at the same rate as the 20 volt battery, what is the value of E?

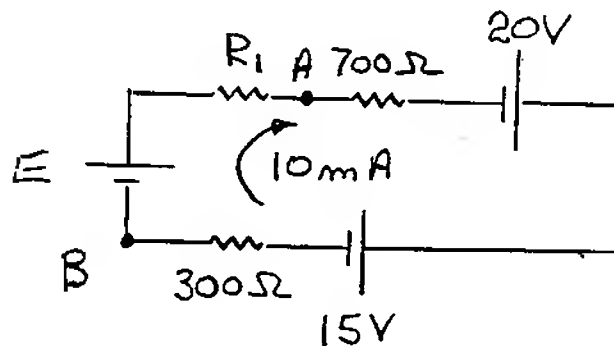


Figure 3

- (4) 6. (a) A series circuit is shown in Figure 4. The power dissipated by resistor R_2 is twice that of R_1 and the power dissipated by resistor R_3 is three times that of R_1 . What is the voltage across R_2 , i.e. V_{AB} .
- (b) What is the voltage of battery E in the circuit shown in Figure 5 if the current is 300 mA in the clockwise direction? The sign of your answer must be correct to get full credit for this question.

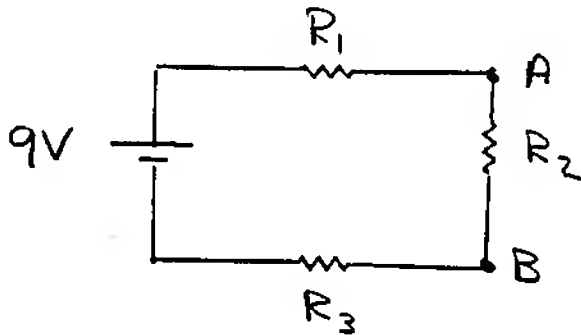


Figure 4

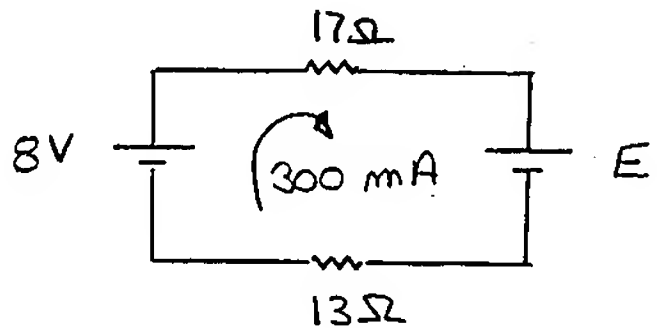


Figure 5

- (4) 7. A series circuit is shown in Figure 6. The current is 20 mA in the counter-clockwise direction. What is $V_A - V_B$?

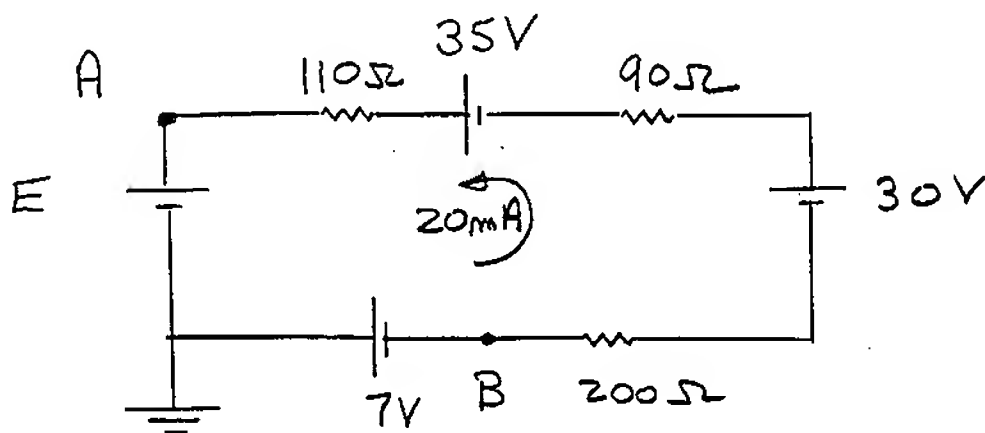


Figure 6